



Impact of the MJO on tropical storms in the ECMWF EPS

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Outline

- 1. Improvements in the simulation of MJO and TCs at ECMWF**
- 2. Hindcast Experiment**
- 3. Impact of the MJO on model tropical storms**
- 3. Conclusion**

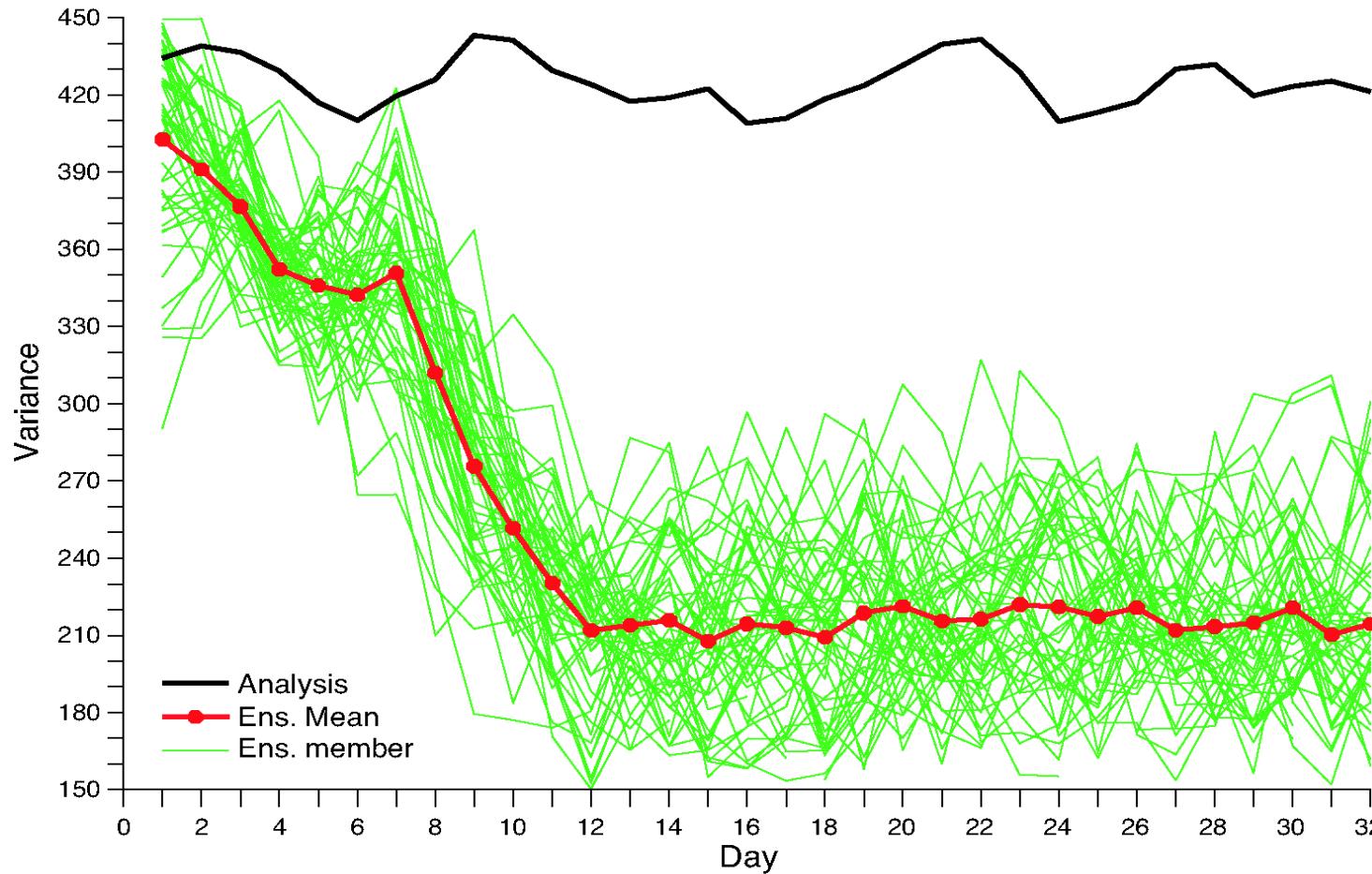


Observational studies

- **Western North Pacific:**
Nakazawa (1988); Liebmann et al (1994)
- **Eastern North Pacific:**
Molinari et al, (1997); Maloney and Hartmann (2000)
- **Gulf of Mexico:**
Maloney and Hartmann (2000); Mo (2002)
- **South Indian Ocean:**
Bessafi and Wheeler (2006); Ho et al (2006)
- **Australian region:**
Hall et al (2001)
- Impact on tropical cyclone genesis index: Camargo et al (2009)

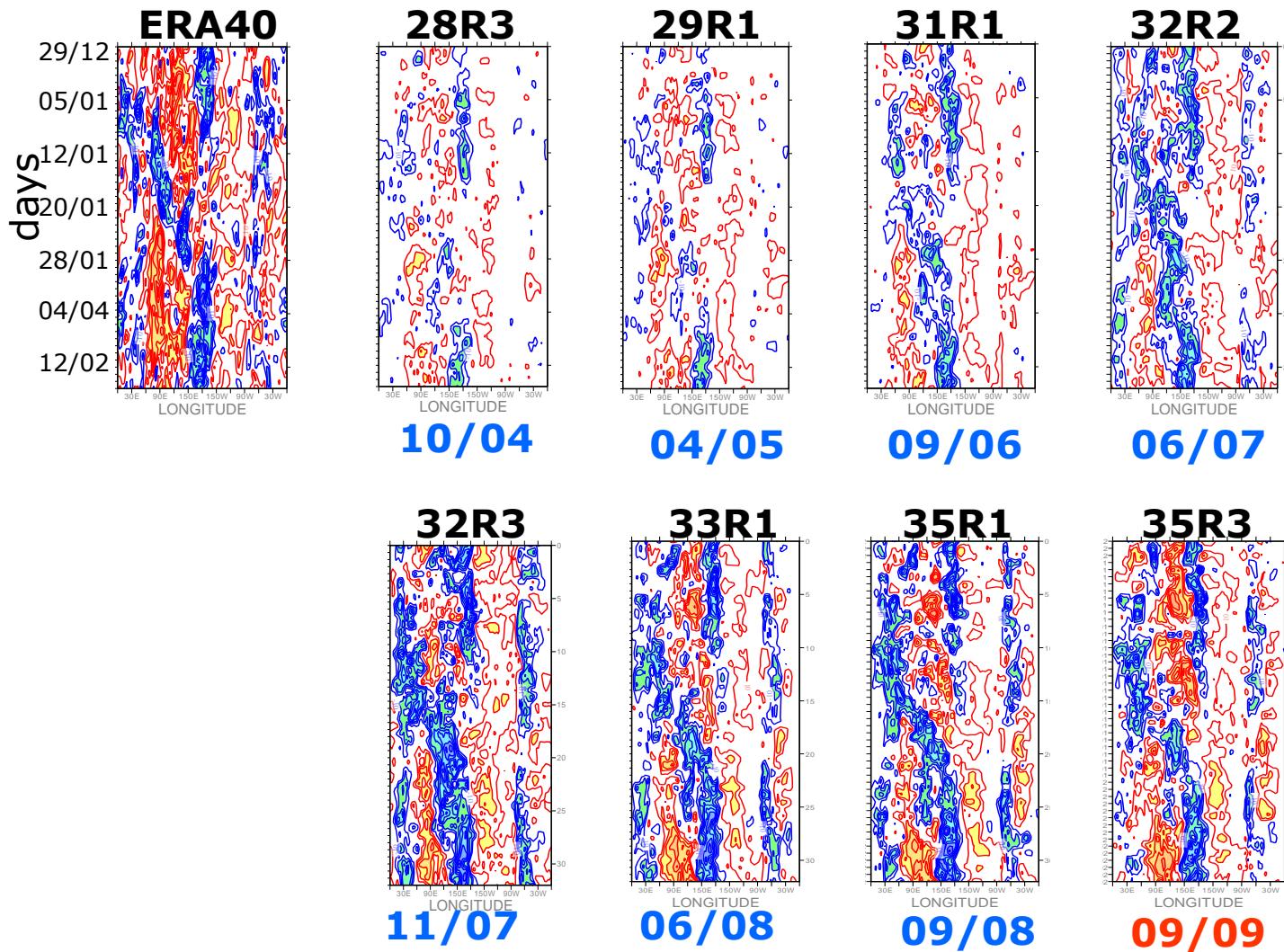
Velocity potential

PC1





OLR- Forecast range: day 15





Convection changes to operational massflux scheme (CY32R3)

New formulation of convective entrainment:

Previously linked to moisture convergence

- Now more dependent on the relative dryness of the environment

New formulation of relaxation timescale used in massflux closure:

Previously only varied with horizontal resolution – Now a variable that is dependent on the convective turnover timescale i.e. variable in both space and time also

Impact of these changes is large including a major increase in tropical variability

Bechtold et al, QJRMS, 2008



Tropical Cyclone Tracking (Vitart 1997, 2003)

Step 1: Detection of intense vortices with a warm core for each time step:

- A local maximum of 850 hPa vorticity is located
- The closest minimum of sea level pressure is defined as the centre of the storm
- Detection of a warm core above the centre of the storms

Step 2: Connect the vortices into tracks:

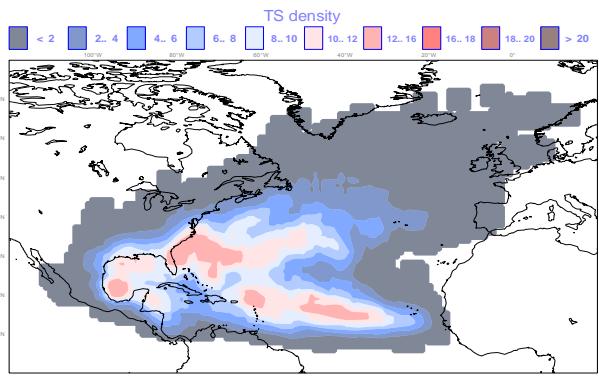
- The steering wind is used to compute a first guess.
- maximum wind velocity at 10m should exceed 17 m/s. Criteria are resolution dependent.



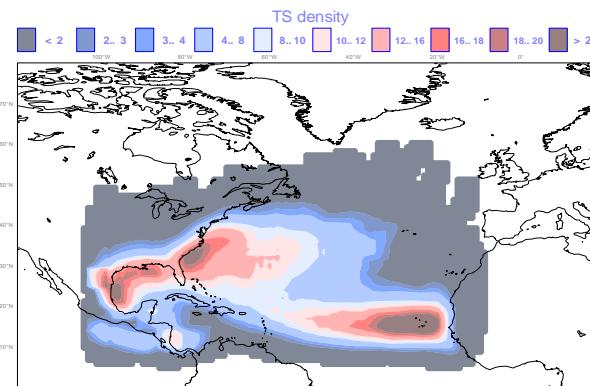
Tropical storm climatology: 1978-2007- ASO

Number of tropical storm days within 2 degrees

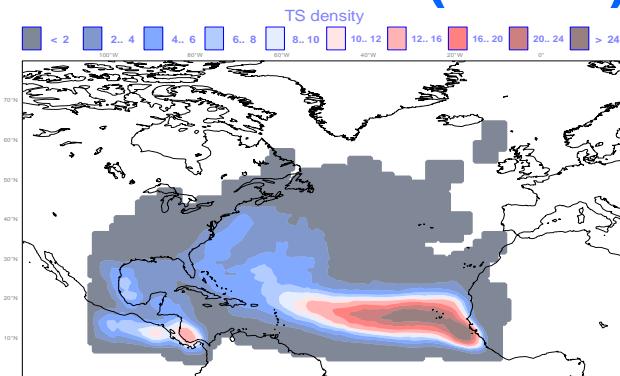
HURDAT



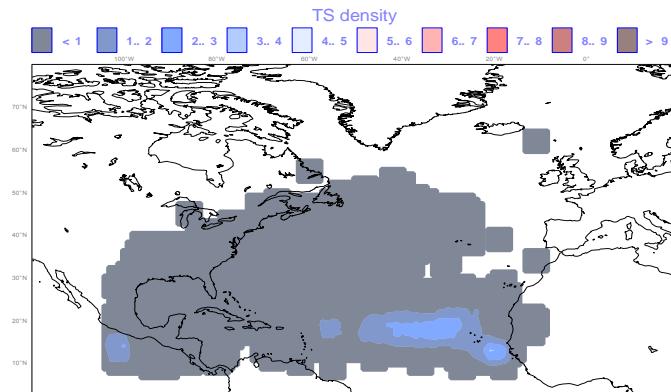
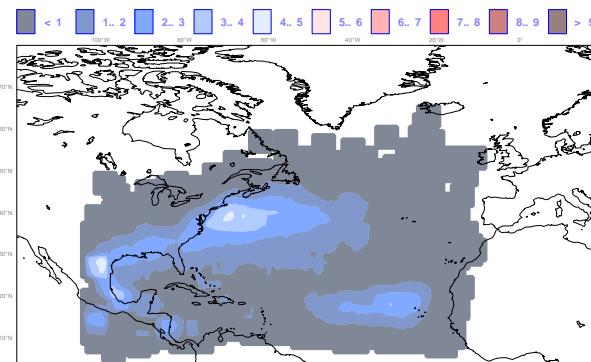
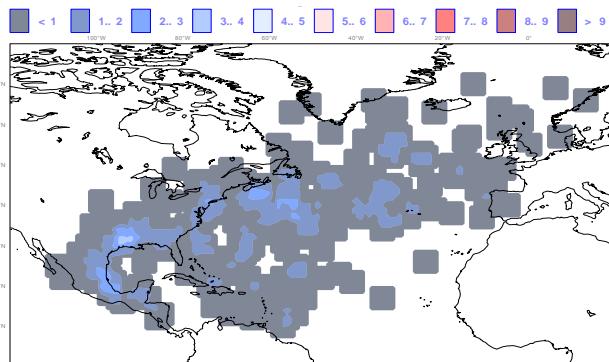
CY32R3



CY30R1 (SYS3)



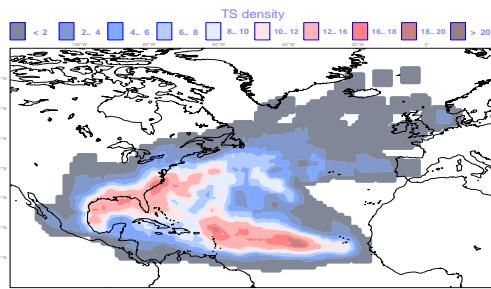
Number of tropical storm last day within 2 degrees





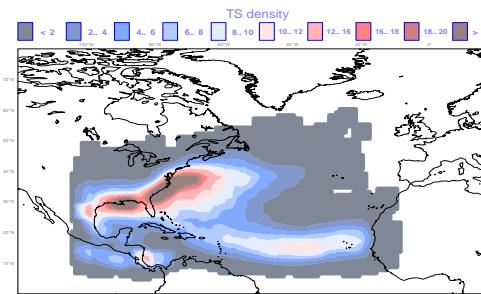
Number of tropical storm days within 2 degrees

HURDAT

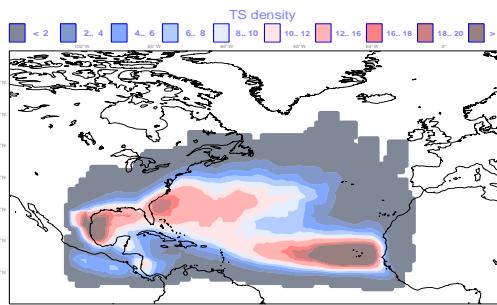
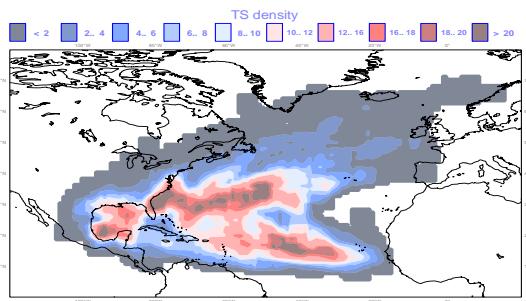


AUG.

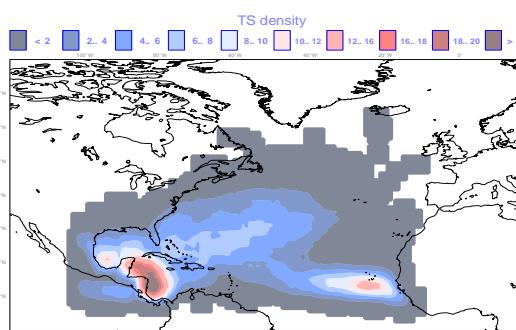
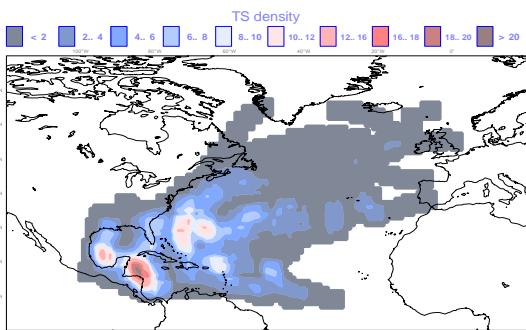
EPS



SEPT.



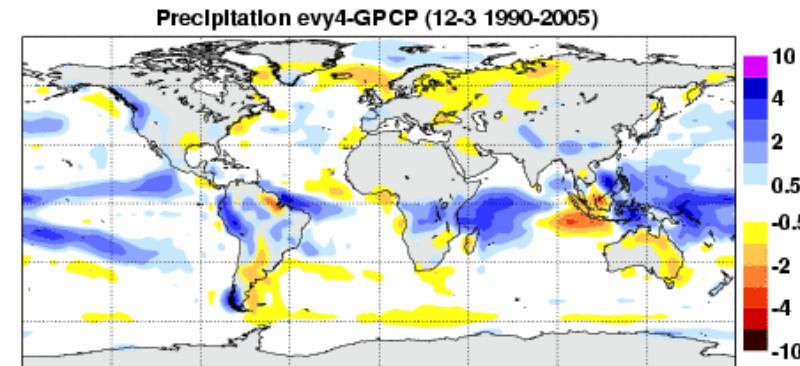
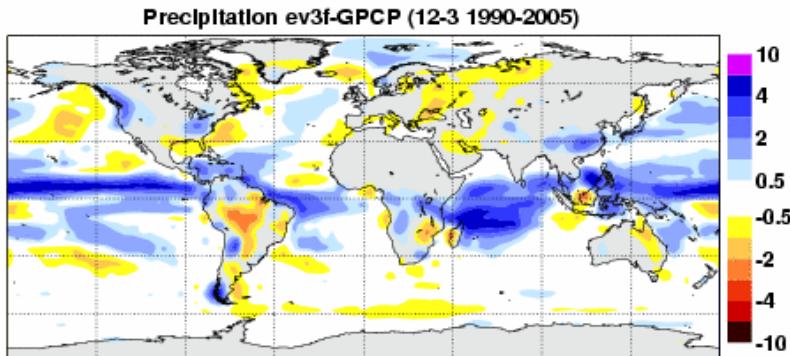
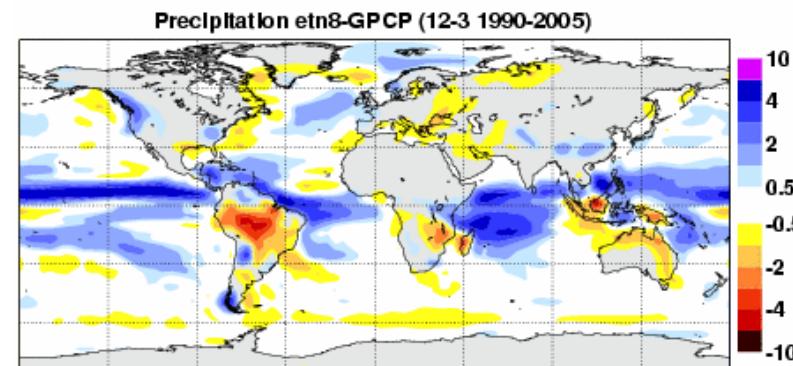
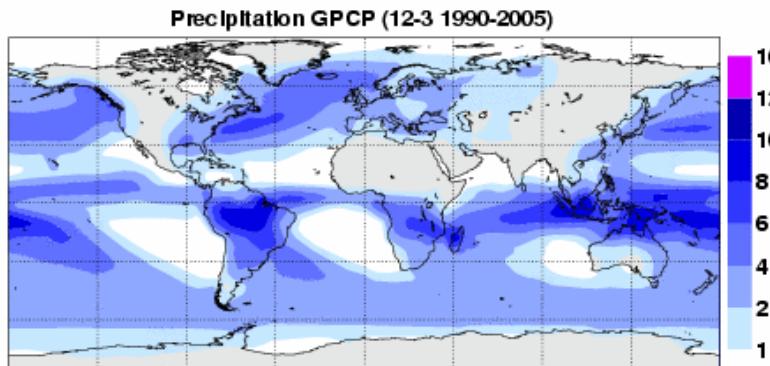
OCT.





Forecast Biases

Precipitation for DJF against GPCP for different cycles: from 15 year 5 months integrations for 1990-2005.



CY32R2 June 2007

CY32R3 Nov 2007

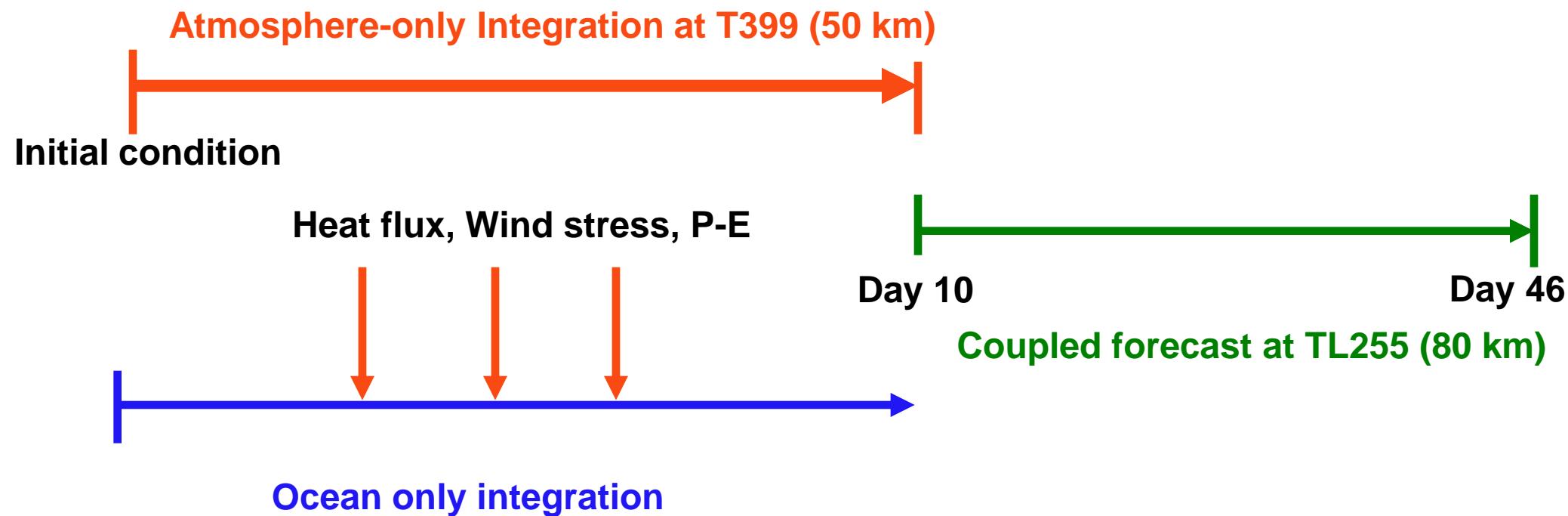


Hindcast Experiment

- 15-member ensemble forecasts starting on the 15th of each month from 1989 to 2008.
- 46-day integrations
- Cycle 32R3
- T399 (50 km) uncoupled till day 10 and T255 (80km) coupled after day 10



Experimental setup





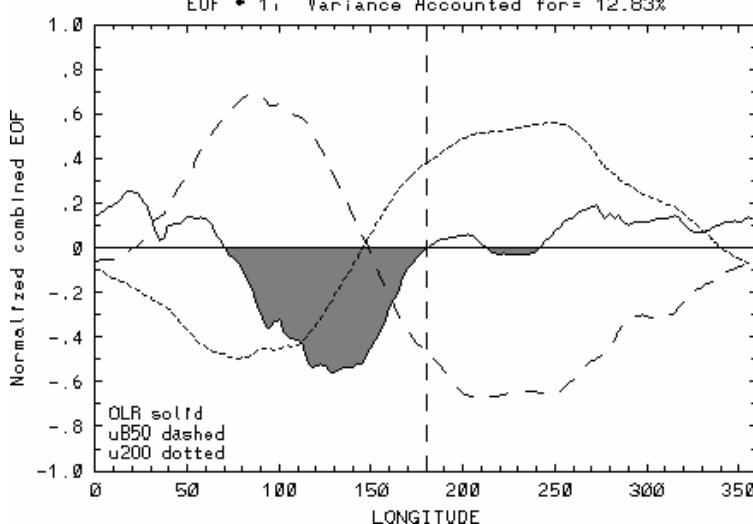
46-day hindcast experiment

- Atmospheric initial conditions: ERA40 + ECMWF operational analysis
- Oceanic initial conditions: ECMWF Ocean Reanalysis
- Perturbations:
 - Atmosphere: Singular vectors + stochastic physics
 - Ocean: wind stress perturbations during data assimilation.

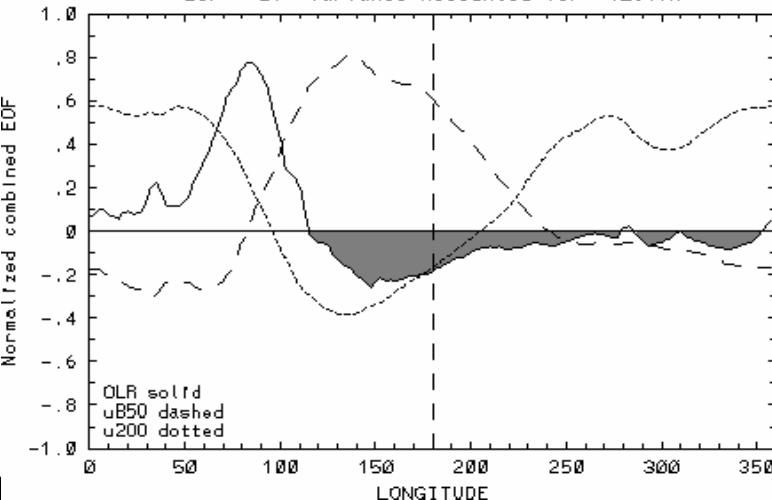


MJO Diagnostics

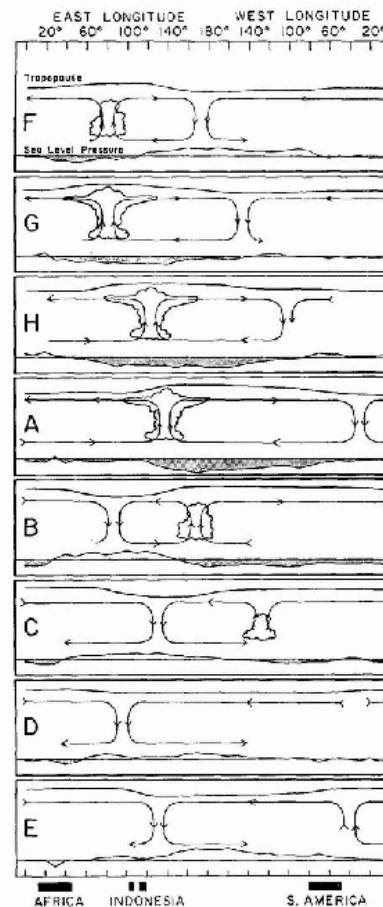
Combined EOF1



Combined EOF2



Madden and Julian's (1972) schematic



} Like negative EOF 2

} Like positive EOF 1

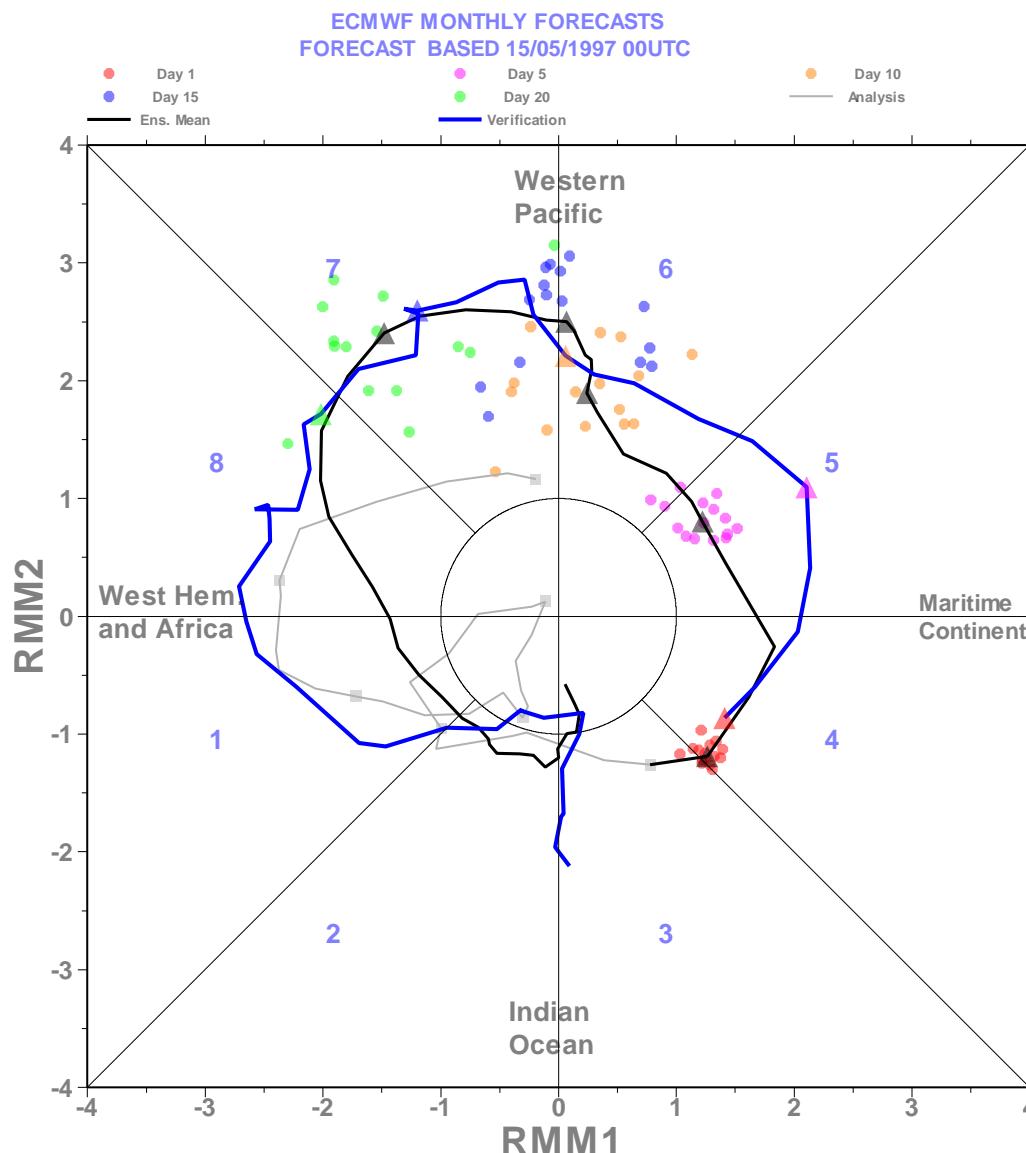
} Like positive EOF 2

} Like negative EOF 1

From Wheeler and Hendon, BMRC

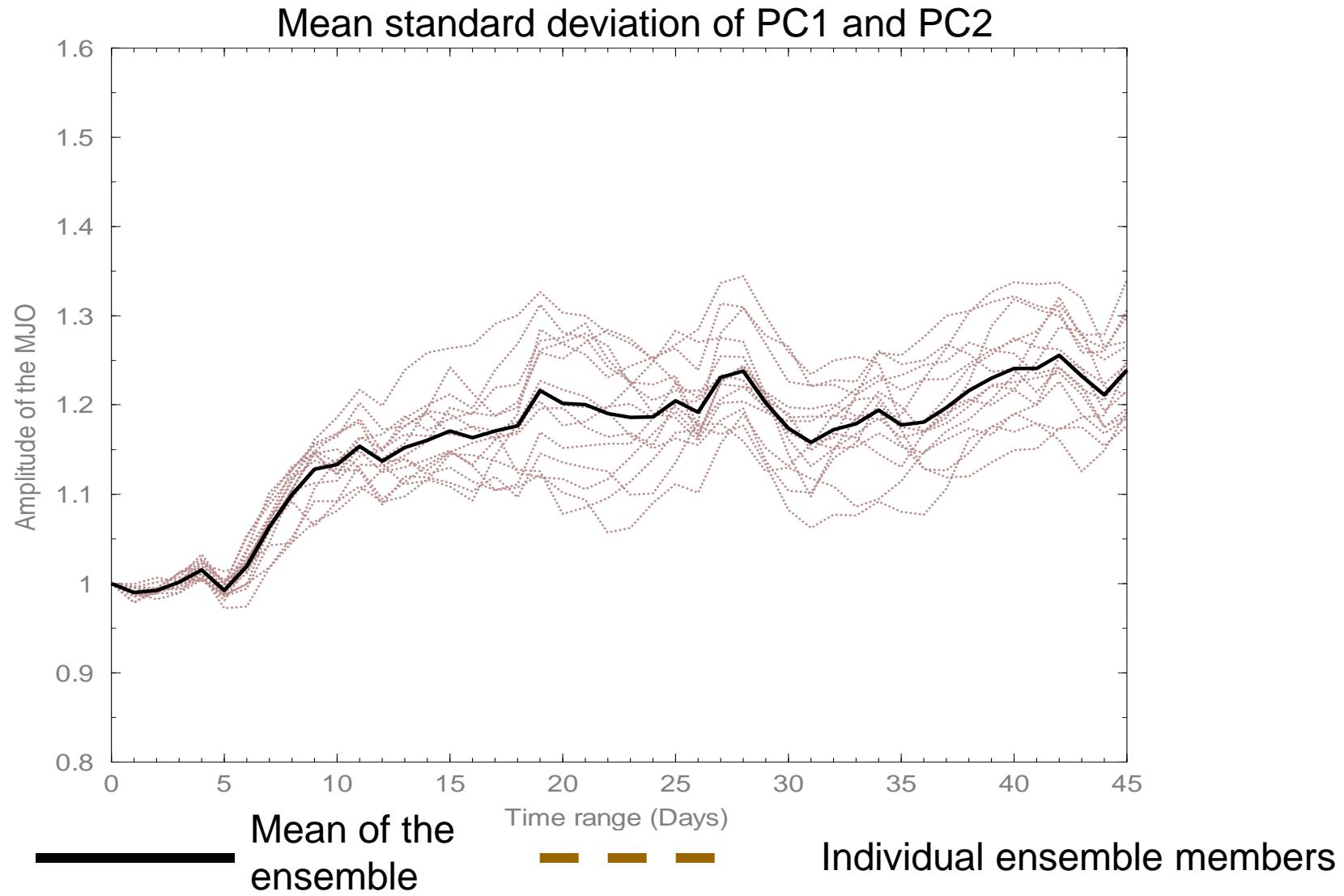


MJO FORECAST





Amplitude of the MJO

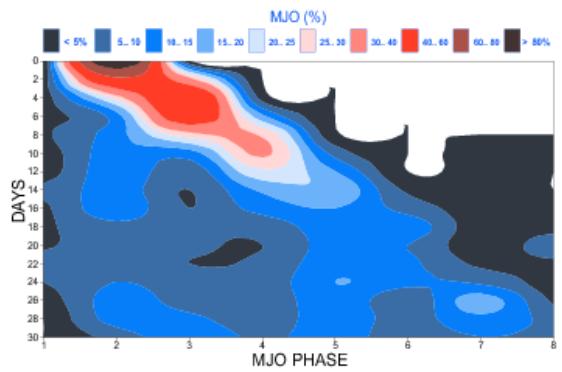




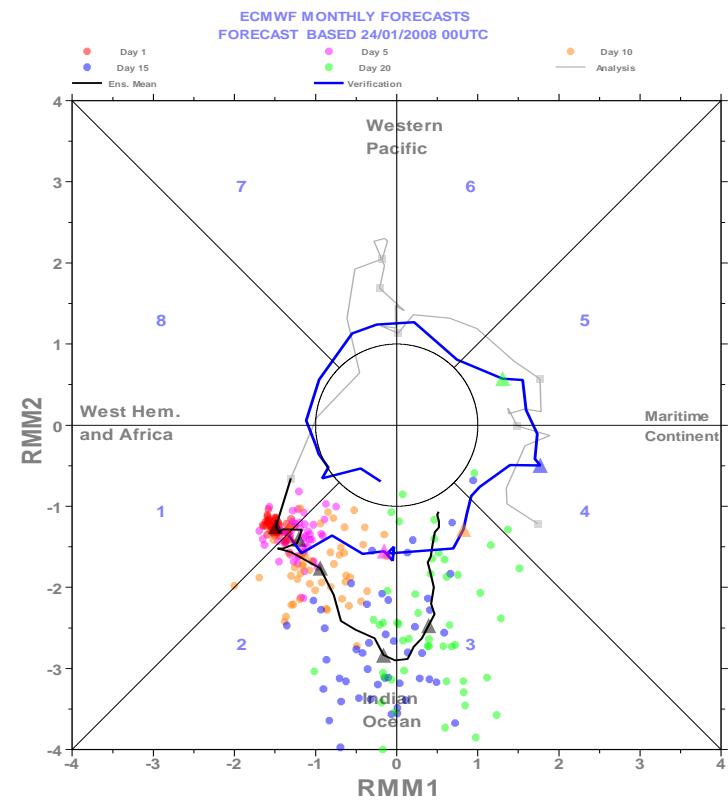
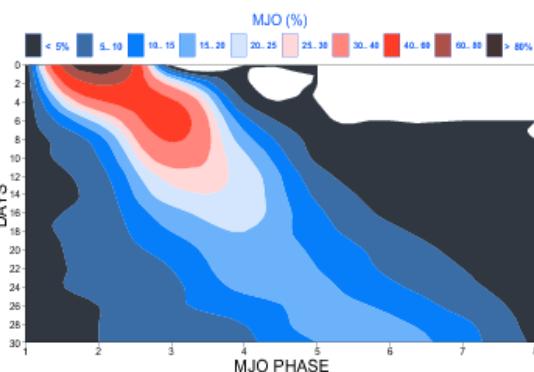
MJO Propagation

MJO Propagation

Analysis



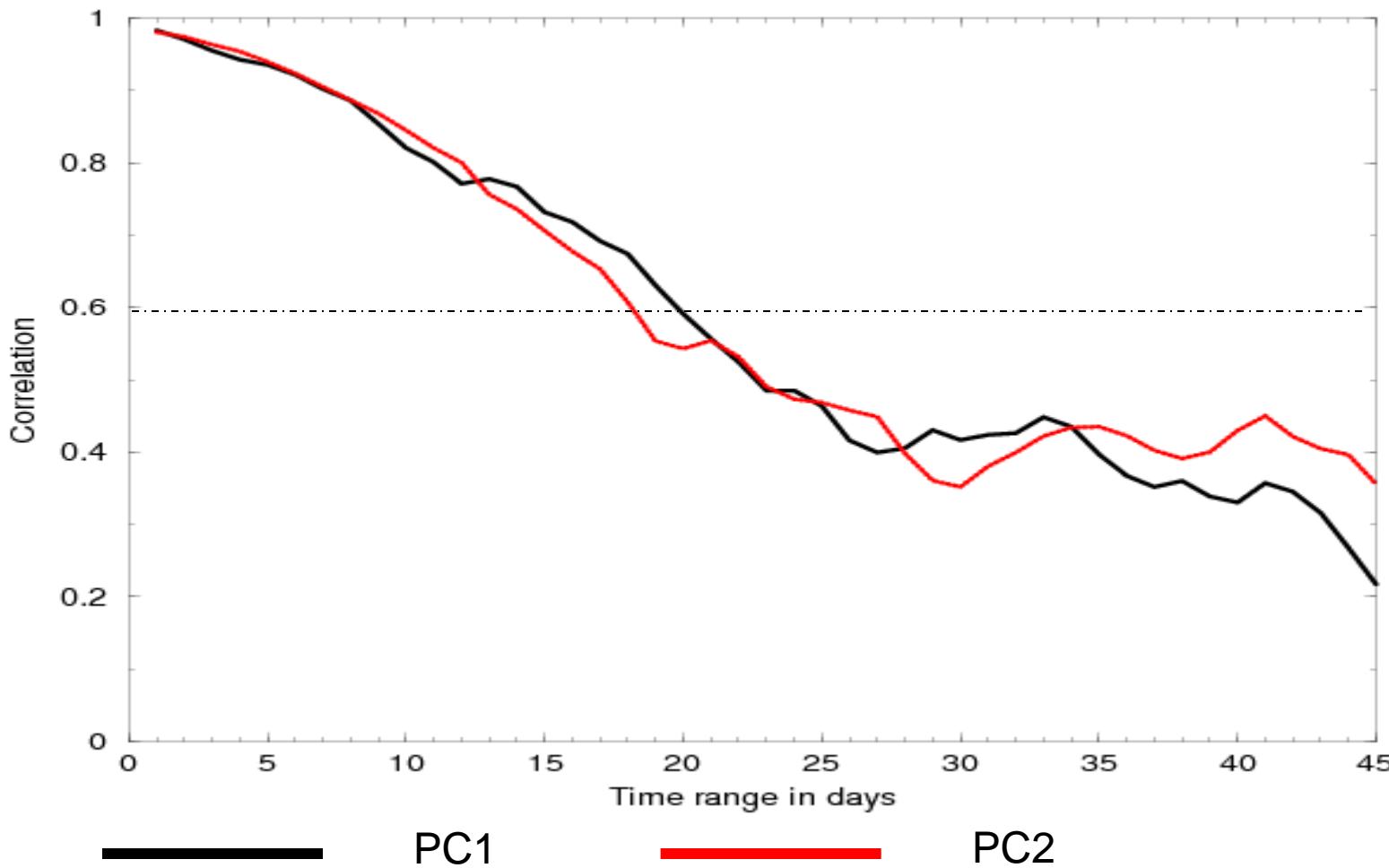
Forecast





Skill to predict MJO

Correlation with analysis (ERA Interim)



PC1

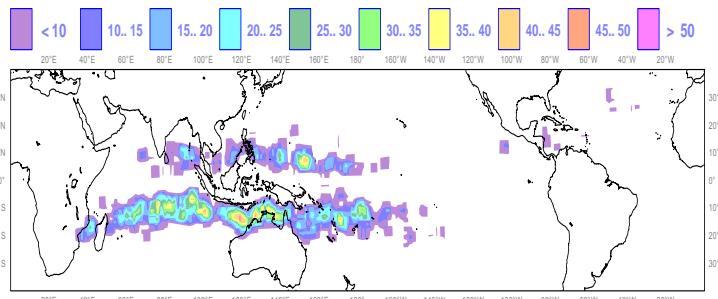
PC2



Tropical Cyclone Genesis climatology

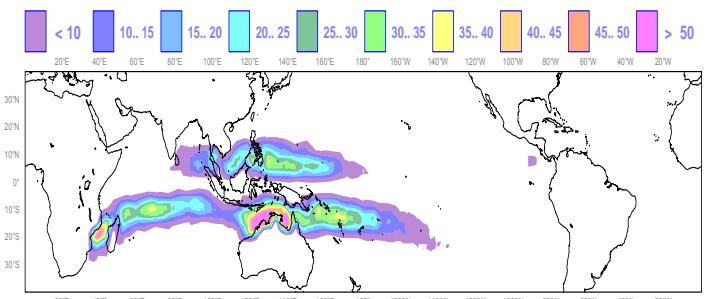
1989-2008

Observations

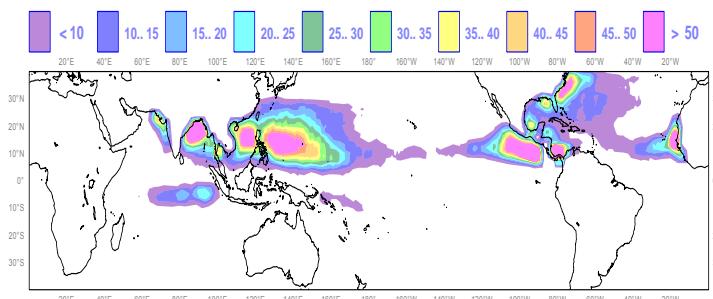
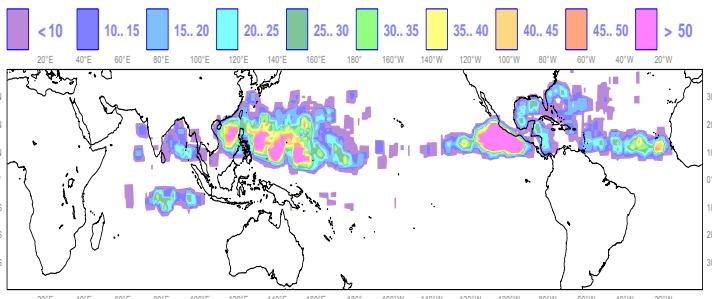


NDJFMA

Model



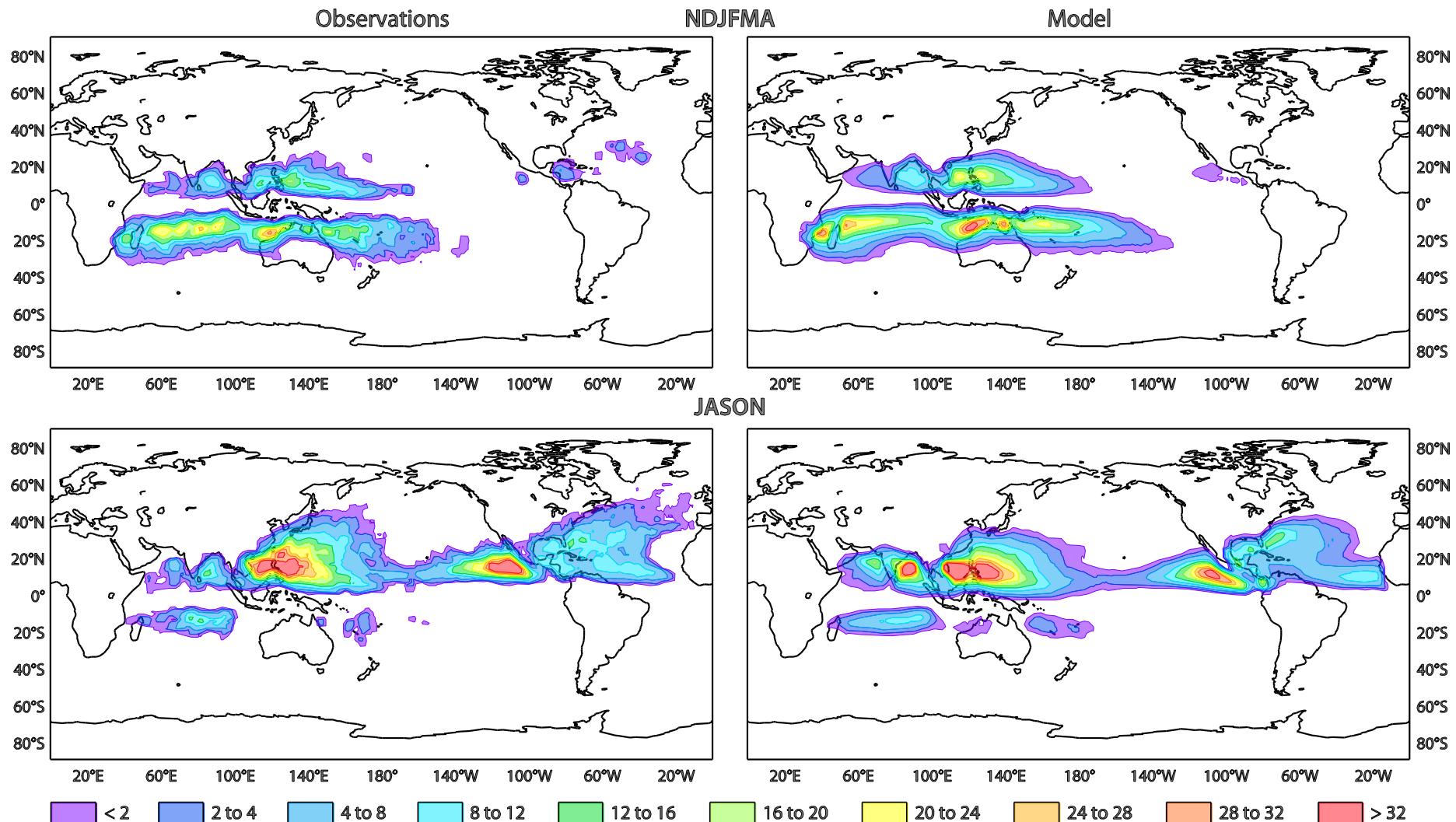
JASON





Tropical Cyclone Density climatology

1989-2008





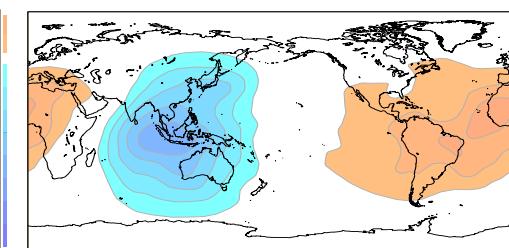
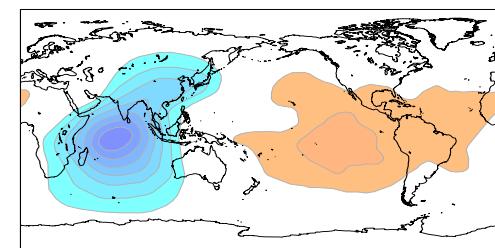
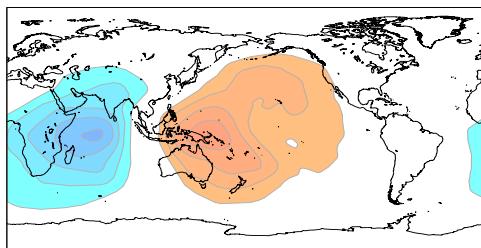
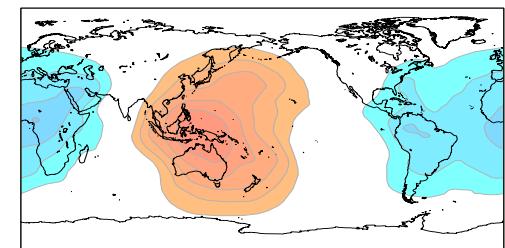
MJO Composites of VP200 hPa

Phase 1

Phase 2

Phase 3

Phase 4

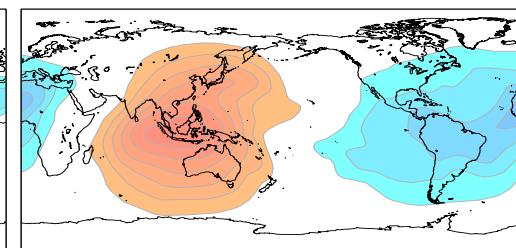
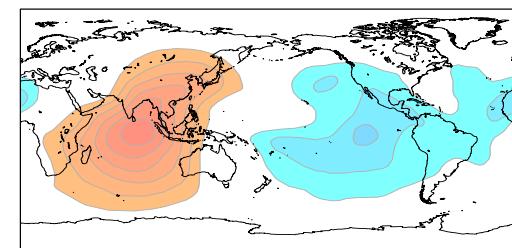
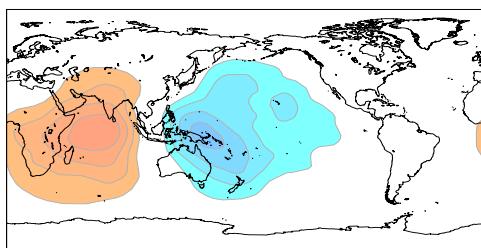
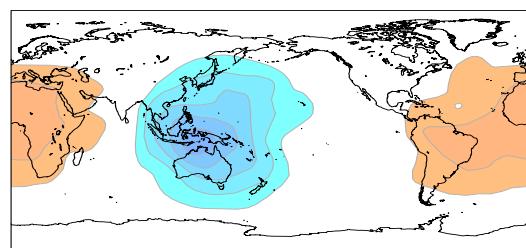


Phase 5

Phase 6

Phase 7

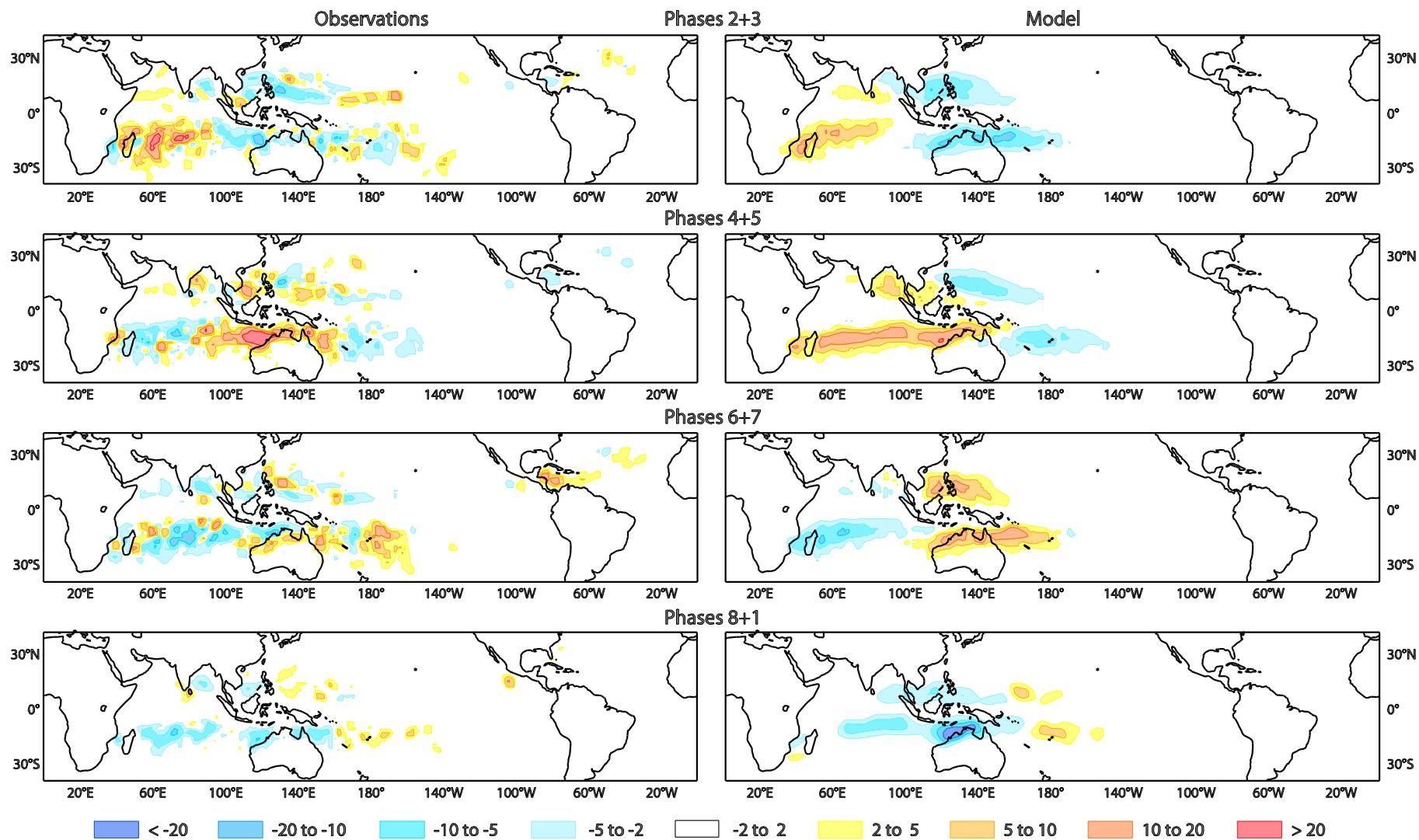
Phase 8





MJO Composite- NDJFMA

Tropical storm density anomaly

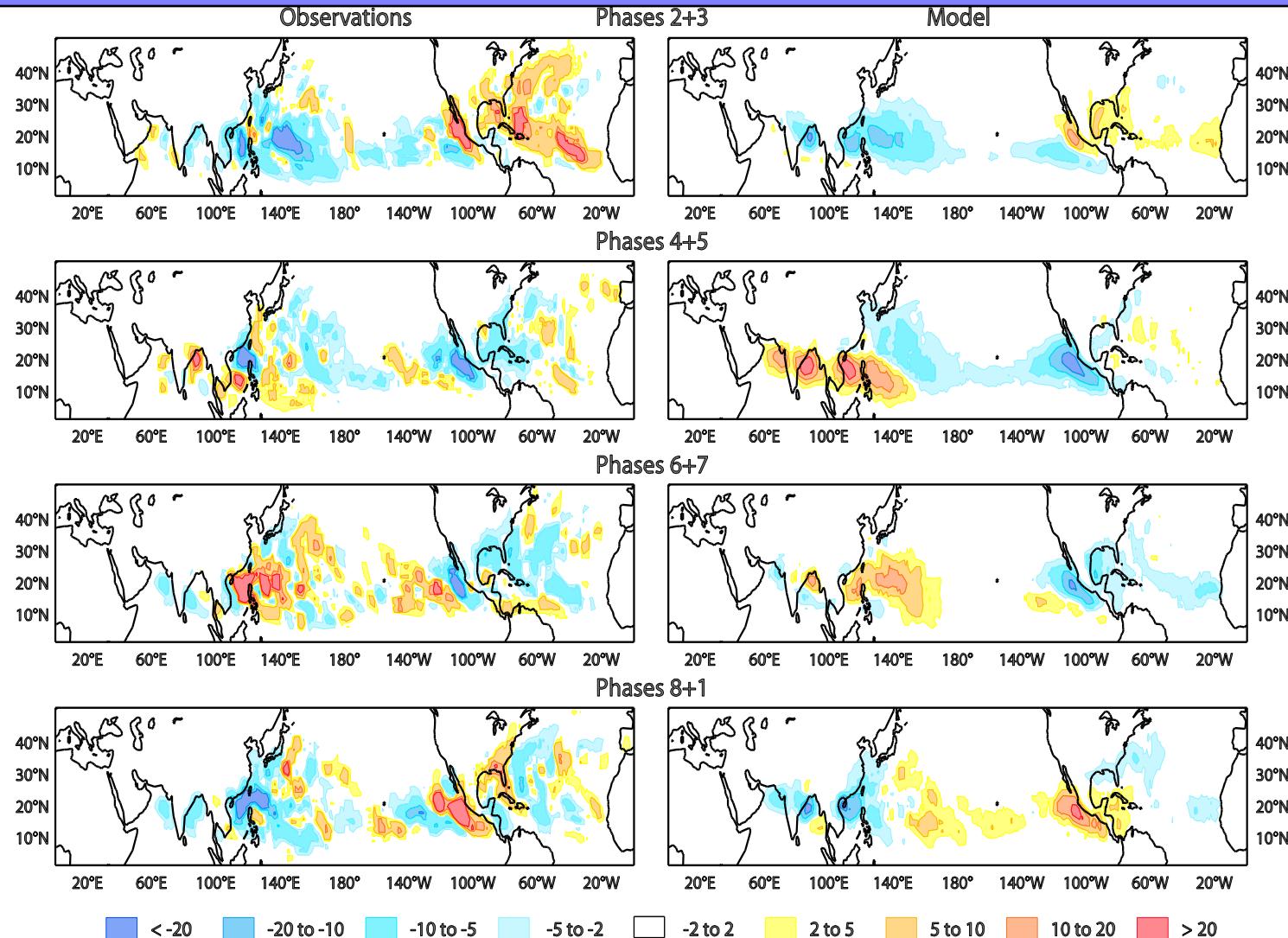


Vitart, 2009, GRL



MJO Composite- ASO

Tropical storm density anomaly



Vitart, 2009, GRL

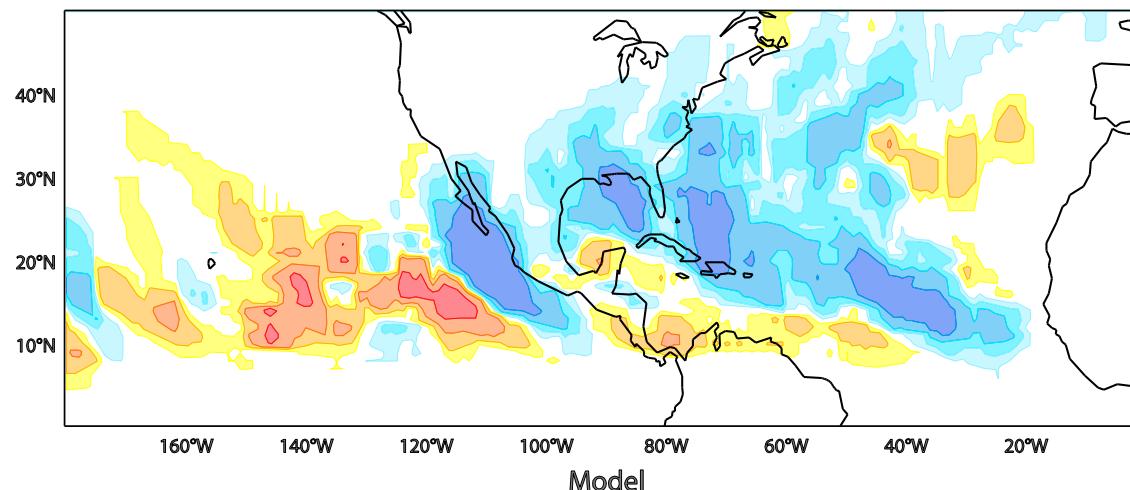


MJO Composite- ASO

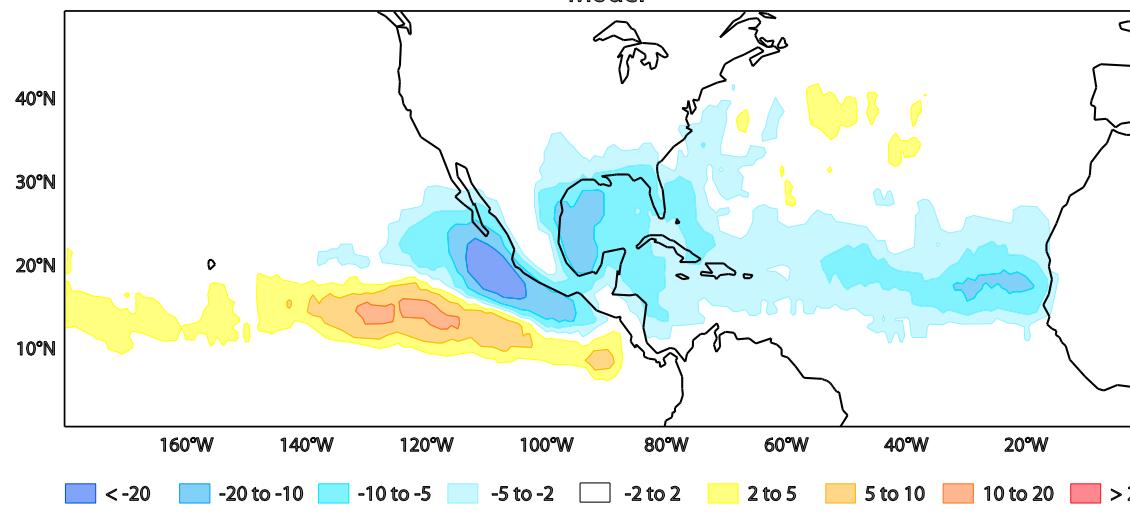
Tropical storm density anomaly

Phases 6+7 – Phase 2+3

Observations



Model



<-20 -20 to -10 -10 to -5 -5 to -2 -2 to 2 2 to 5 5 to 10 10 to 20 >20

Vitart, 2009, GRL



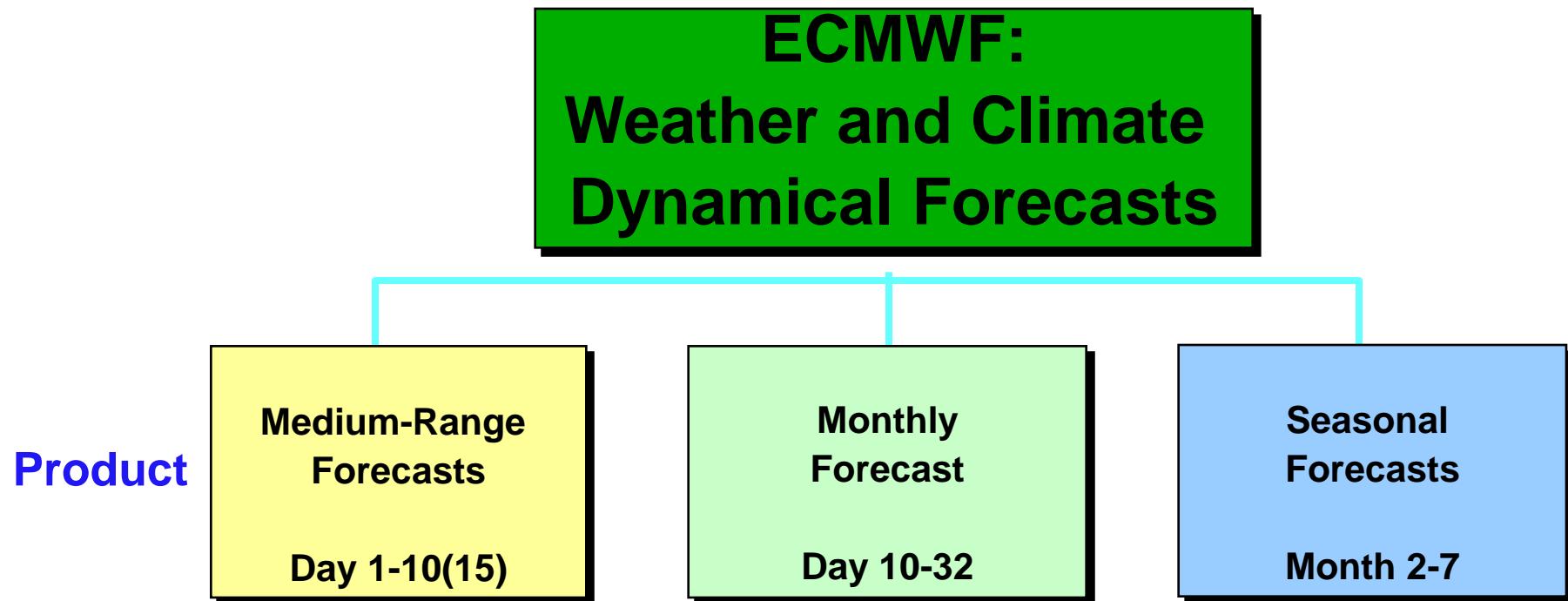
Landfall Activity

	Australia NDJFMA	South+East US Coast ASO	West Coast US+Mexico ASO
Phase 2+3	-50% (-30%)	+45% (+73%)	+43% (+100%)
Phase 4+5	+50% (+96%)	-16% (-56%)	-22% (-68%)
Phase 6+7	+71% (+25%)	-30% (-71%)	-37% (-83%)
Phase 8+1	-22% (-70%)	+9% (+80%)	+39% (+100%)

Vitart, GRL, 2009



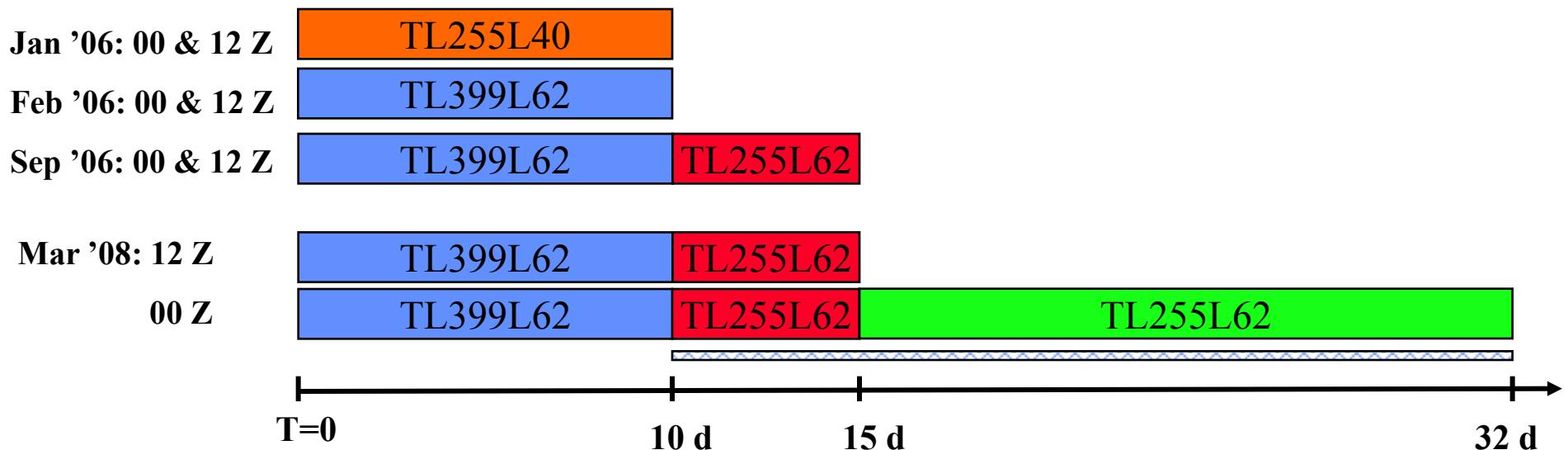
Forecasting systems at ECMWF





The seamless EPS/monthly ensemble system

On the 11th of Mar '08 the 15-day variable resolution EPS (VAREPS) was merged with the monthly ensemble system; since then the 00 UTC forecasts use a coupled ocean model from day 10.

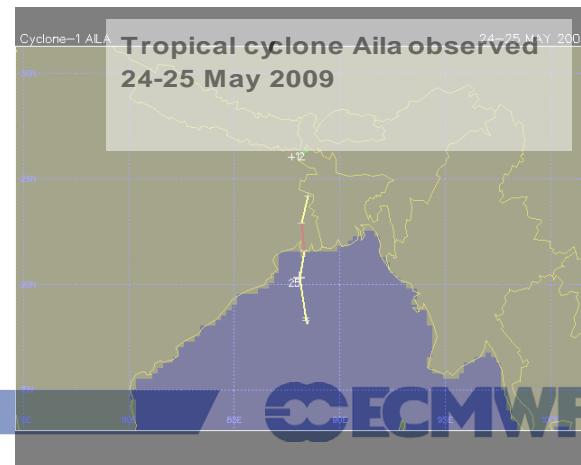
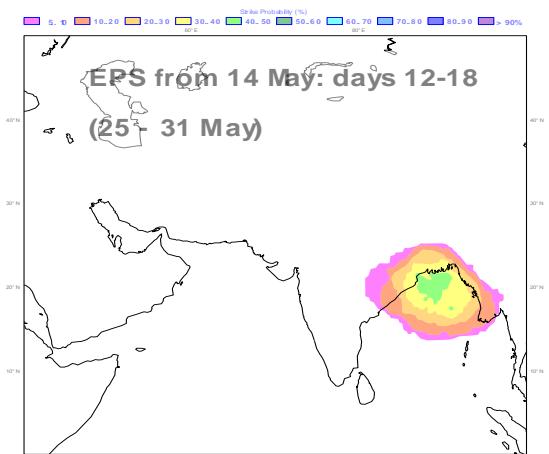
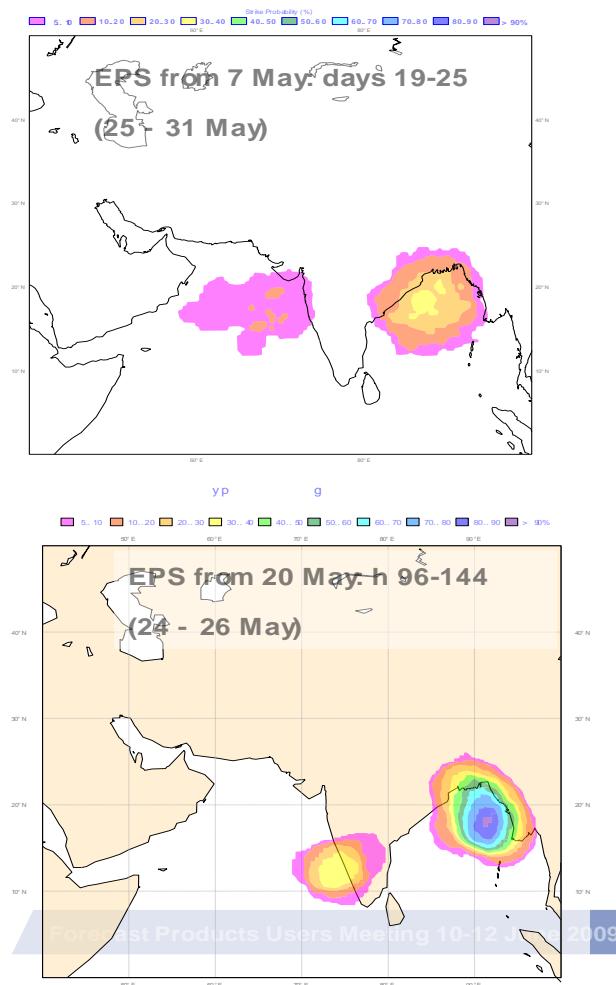


$(T_L399 \sim 50 \text{ km in grid point space}, T_L255 \sim 80 \text{ km})$



Seamless prediction of tropical storms

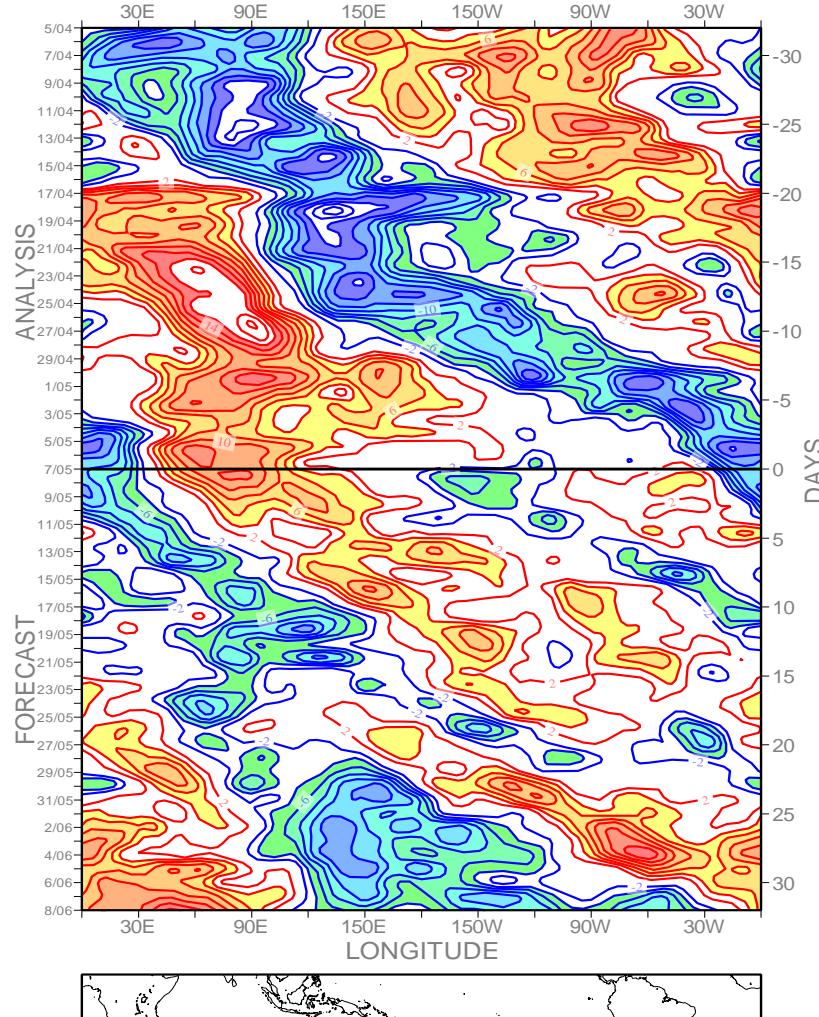
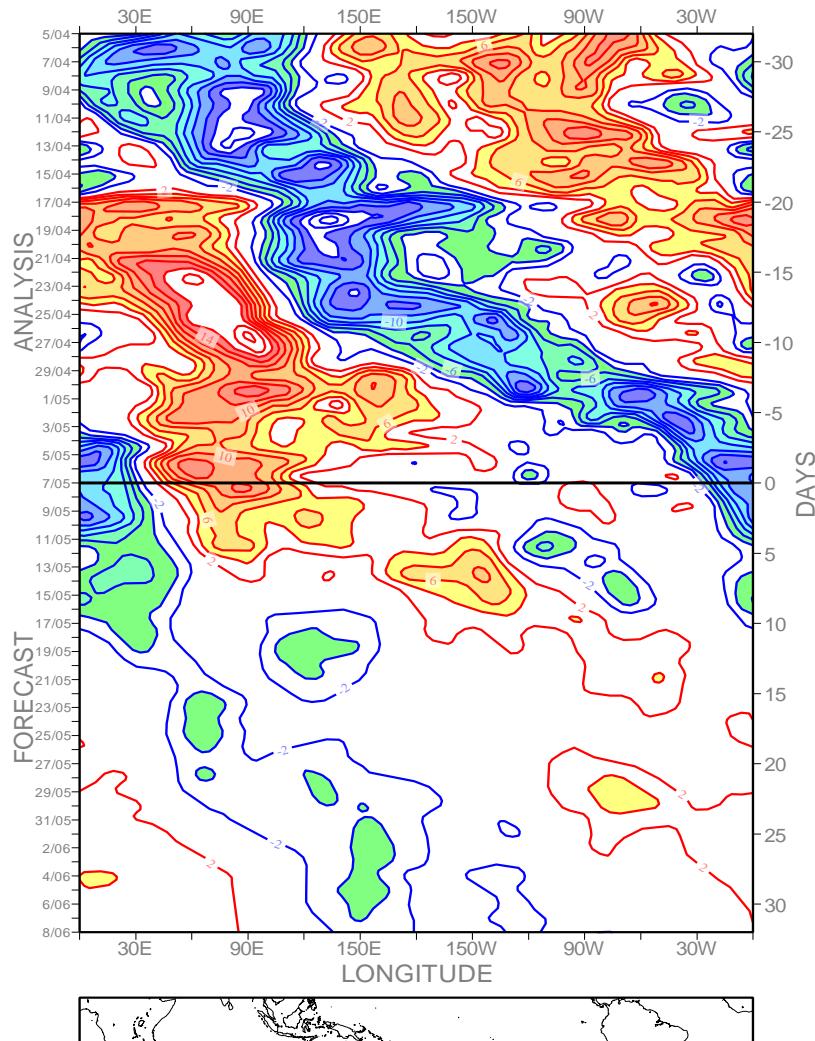
Tropical cyclone Aila (24-25 May 2009)





Monthly prediction Of TC activity

VP200 Anomaly

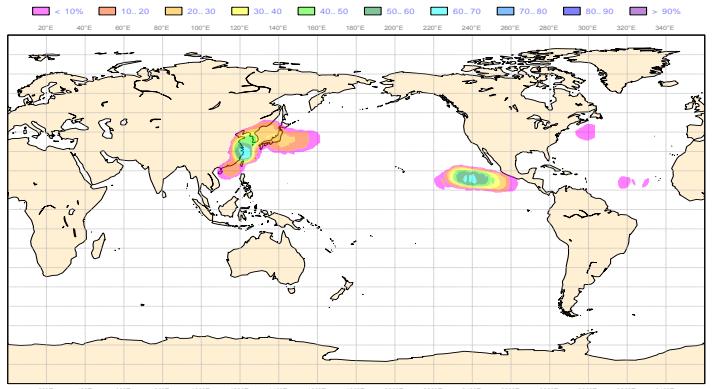




Monthly forecasts of tropical storms- 20090806

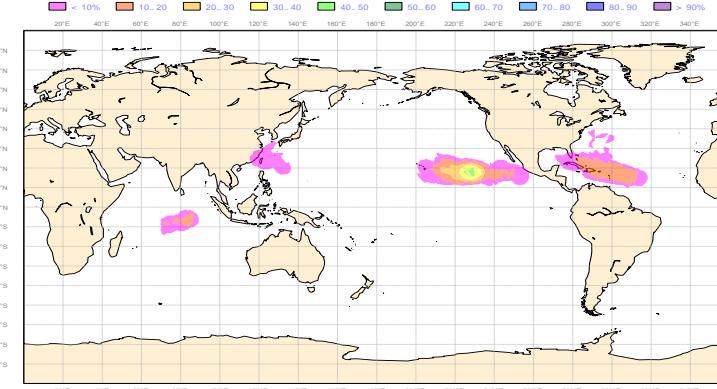
Day 5-11

Weekly mean Tropical Storm Strike Probability. Date: 20090806 0 UTC t+(96-240)
Probability of a TS passing within 500km radius



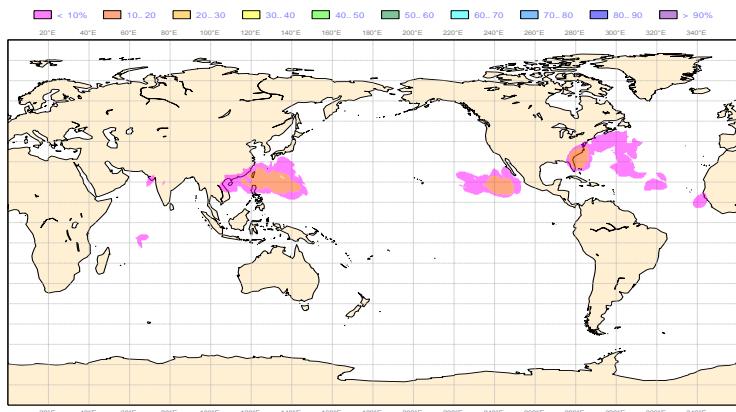
Day 12-18

Weekly mean Tropical Storm Strike Probability. Date: 20090806 0 UTC t+(264-408)
Probability of a TS passing within 500km radius



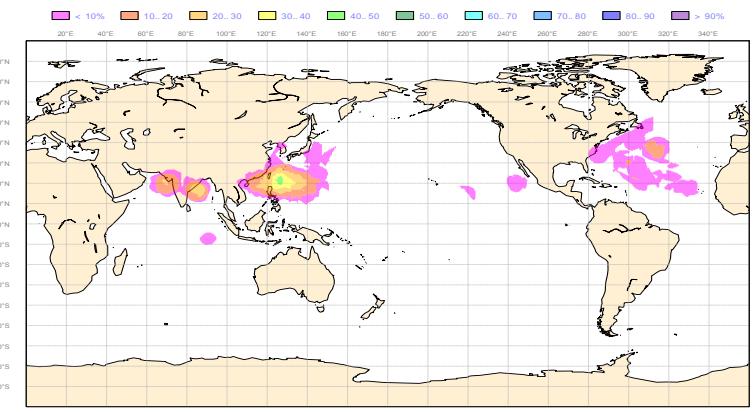
Day 19-25

Weekly mean Tropical Storm Strike Probability. Date: 20090806 0 UTC t+(432-576)
Probability of a TS passing within 500km radius



Day 26-32

Weekly mean Tropical Storm Strike Probability. Date: 20090806 0 UTC t+(600-744)
Probability of a TS passing within 500km radius





Conclusion

- MJO and Tropical Cyclone activity are more realistic since 32R3
- The MJO suffers from a too slow propagation and has difficulties to cross the Maritime Continent.
- The model simulates a realistic impact of the MJO on model tropical storms, although the impact tends to be weaker than observed
- First step towards seamless prediction of tropical storms: merging of the EPS and monthly forecasting systems.